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Nonverbal Behavior Correlated With the Shaped Verbal Behavior of Children

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Children under 6 years old pressed on response windows behind which stimuli appeared (star or tree). Presses occasionally lit lamps arranged in a column; a present was delivered when all lamps were lit. A random-ratio schedule in the presence of star alternated with a random-interval schedule in the presence of tree. These contingencies usually did not produce respective high and low response rates in the presence of star and tree, but the shaping of verbal behavior (e.g., "press a lot without stopping" or "press and wait") was sometimes accompanied by corresponding changes in response rate. Verbal shaping was accomplished between schedule components during verbal interactions between the child and a hand-puppet, Garfield the Cat, and used social consequences such as enthusiastic reactions to what the child had said as well as concrete consequences such as delivery of extra presents. Variables that may constrain the shaping of verbal behavior in children seem to include the vocabulary available to the child and the functional properties of that vocabulary; the correlation between rates of pressing and what the child says about them may depend upon such variables.

When behavior is determined by its consequences, it is called contingency-shaped. For example, the rate of a pigeon's pecks on a key is determined by the schedule according to which its pecks produce food; that rate is higher when food deliveries produced by pecks depend on response number than when they depend on elapsed time (ratio versus interval schedules). Human behavior, however, is often rule-governed rather than contingency-shaped: to the extent that it is determined by verbal behavior, it is determined only indirectly by its consequences (Skinner, 1969). Rule-governed behavior itself is presumably maintained by its consequences, and these consequences are typically socially mediated. To the extent that they produce a higher-order class of behavior called rule-following, verbal antecedents of the behavior may override its nonverbal and nonsocial consequences (cf. Catania, Shimoff, & Matthews, 1989).

These properties of rule-governed behavior have been examined experimentally with adults (e.g., Catania, Matthews, & Shimoff, 1982; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Matthews, Catania, & Shimoff, 1985; Shimoff, Matthews, & Catania, 1986). In one study, a student's presses on left and right buttons occasionally produced points later exchangeable for money. Lights above the buttons lit alternately, indicating which button was operative. A number-based

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schedule operated for the left button (random ratio or RR: the last of a random number of presses produced a point) and a time-based schedule for the right button (random interval or RI: the first press after a random time since the last point delivery produced a point). Between periods of responding, the student completed sentences such as "The way to earn points with the left button is to...." Points awarded for sentence completions were used to shape verbal behavior, i.e., they were awarded for successively closer approximations to particular statements about performance (cf. Greenspoon, 1955).

The nonverbal performance, button pressing, was typically determined not by the contingencies arranged for pressing but rather by the student's verbal behavior. The shaping of statements that points depended on slow left pressing and fast right pressing produced corresponding pressing rates, slow left and fast right, even though these schedules respectively produce high and low rates in nonhuman contingency-shaped performances.

The correlation between shaped verbal behavior and nonverbal responding in adults presumably has its antecedents in the contingencies that operate on the verbal and nonverbal behavior of children,

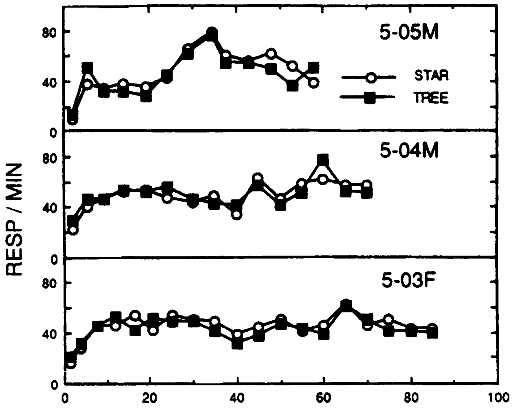

Fig. 1. Effects of low-rate contingencies during star and high-rate contingencies during tree on the multiple-schedule response rates of three children. The children are identified by age in years and months (Y-MM) and by gender (F or M). Over roughly 2 to 3 hours of multiple-schedule components, these rate contingencies did not produce differential response rates.

and the present research was designed to explore with children the effects of procedures analogous to those used with adults. The transition from contingency-shaped performances that resemble those of nonhuman organisms to the rule-governed performances that are characteristic of human adults seems usually to occur some time between 2 and 6 years of age (Bentall, Lowe &, Beasty, 1985; Lowe, Beasty, & Bentall, 1983). The differential responding reliably obtained with nonhuman organisms (such as the higher rates maintained by ratio than by interval schedules) is likely to be absent in the behavior of children more than 5 years old.

Figure 1 provides an example. Star and tree, presented by a computer monitor behind response windows, were the two stimuli of a multiple schedule arranged for a child's presses. The presses occasionally lit lamps arranged in a column; a present was delivered when all lamps were lit. Alternating components lasted 60 s each. In the first (star), an RI 10-s schedule arranged consequences for satisfying a low-rate contingency; in the second (tree), it did so for satisfying a high-rate contingency (see Catania, Horne, & Lowe, 1989, for details).

Data from three children are shown (each child is coded by age in years and months, Y-MM, and by gender, F or M; 5-05M is the child whose data are reported in Catania, Horne, & Lowe, 1989). Unfilled circles show rates from the low-rate component (star); filled squares show rates from the high-rate component (tree). The low-rate and high-rate contingencies were introduced after 3 or 4 sessions of multiple RI RI schedules. The plan was to increase the stringency of the rate requirements gradually over sessions so as to produce a rate during the high-rate component two to four times higher than that in the low-rate component. Over successive sessions, no separation of response rates occurred. Those sessions included many periods during which the low-rate and high-rate contingencies were either or both satisfied, but such periods were not consistently followed by continuations of the performances that had satisfied those contingencies. In subsequent sessions for each child, however, verbal interventions rapidly produced differential response rates in the two components.

Demonstrating reduced sensitivity to schedule contingencies with age leaves open the question of the basis for that reduced sensitivity. It can be argued that older children have longer histories of contact with ranges of contingencies and that these histories interact with effects of schedules (cf. Wanchisen, Tatham, & Mooney, 1989), or that the effectiveness of reinforcers varies with age and that reinforcers arranged for the behavior of older children are not comparable to those used with infants or nonhumans (cf. Perone, Galizio, & Baron, 1988), or that verbal behavior involves social contingencies for rule-following that interfere with the direct effects of nonverbal contingencies (cf. Catania, Matthews, & Shimoff, 1990).

Performances that are insensitive to schedule differences, such as those of Figure 1, might be changed to sensitive ones by providing more exposure to the schedules, by arranging different histories, by varying schedule parameters, by switching to different reinforcers, or by manipulating verbal behavior. But demonstrating an effect of any one of these variables does not in itself establish that variable as the source of the insensitivity. For example, a performance that originated as an instance of rule-following might nevertheless be susceptible to variations in experimental history, schedule parameters or reinforcer magnitudes.

Whatever the source of the insensitivity to contingencies, rule-governed behavior is demonstrated when such performances can be modified by manipulating verbal behavior. The present account is concerned primarily with the effects of shaped verbal behavior, and describes attempts to replicate with children the shaping of verbal behavior and the correlated changes in nonverbal performance that have been obtained with adults. It should therefore be regarded as an exploratory study that identifies some procedural prerequisites and pitfalls in the maintenance of the nonverbal behavior of children and in the shaping of their verbal behavior.

METHOD

Subjects

Children were selected for the study on the basis of age and times of availability from classes of the Cae Top elementary school in Bangor, North Wales. As judged by their teachers, all were fluent in English at levels appropriate to their ages; some were bilingual Welsh and English speakers. The continued participation of each child depended on uncontrollable factors such as apparatus problems or reliability of attendance (especially owing to illness or family holidays). The 7 girls and 7 boys who served in various stages of the experiment ranged in age from 4-02 to 5-11; each child for whom data are presented is identified by an arbitrary 2-letter code followed by age in years and months at the start of participation (Y-MM) and gender (F or M). No data from children for whom verbal

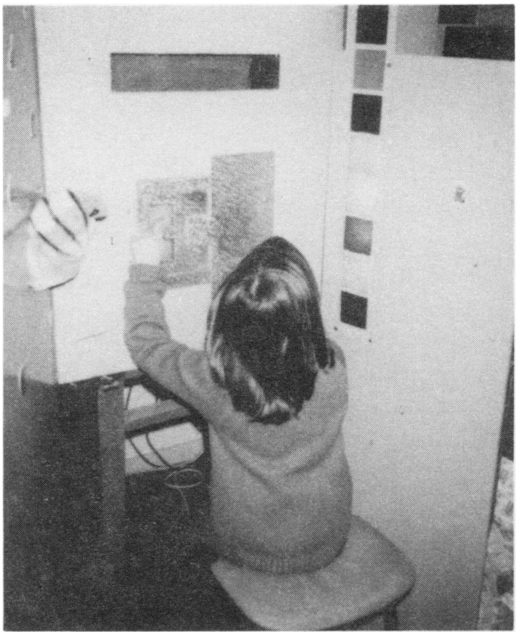

Fig. 2. A child pressing a window on the experimental panel. A computer monitor behind the two response windows presents stimuli. The five bottom column lamps on the right panel have been lit; a present will be placed on the shelf near the top of the center panel when the child has lit the remaining three. Garfield the Cat, a hand puppet, looks on from the left panel.

shaping was successful have been excluded, except for one case in which verbal shaping was followed by sessions that included explicit instructions.

Apparatus and setting

Figure 2 shows a child seated before the main experimental panel, which was clamped to a desk along one wall of a teachers' area (see Catania, Horne, & Lowe, 1989, for additional details). A metal plate on it contained two response windows, each 5-cm square (a metal cover on the right masked three other windows). Stimuli could be presented in the windows by a computer monitor located behind the panel. The monitor was connected to a computer that arranged experimental contingencies. A microphone fastened at the lower left allowed sessions to be recorded on audio cassette. Presents earned by the child were placed on a shelf located behind a Plexiglas-covered opening in the upper part of the panel.

A column of eight lamps behind translucent colored inserts (red, blue, yellow, and white) was mounted on the right extension of the panel. The left extension screened the experimenter(s) and apparatus from the child, and included a curtained opening through which, as shown, a hand puppet (Garfield the Cat) occasionally emerged to interact with the child.

Procedure

Initial sessions. Sessions were conducted on a semi-regular basis during morning and afternoon school hours and varying with other scheduled school activities and occasional absences. The youngest children, from a preschool class, were available only during morning school hours. On the day of the first session, children were escorted individually from their classrooms to the experimental area by a UCNW student who assisted in the procedures. The general procedure arranged for all children is described here for a representative girl.

Upon arrival in the experimental area, the child was given a scrapbook and was helped to write her name in it. Next she was shown sheets of decals with a broad selection of pictures, and then a "treasure chest," a box containing a variety of small toys, drawing materials, etc. She was asked if she would like to play a game in which she could win pictures for her scrapbook and a chance to pick out something from the treasure chest. Upon her assent she was shown to the stool facing the experimental panel, where Garfield the Cat emerged from the curtained opening in the left panel (cf. Figure 2).

Garfield introduced himself, asked the child's name, and explained that she could get presents by lighting up all of the lamps on the right panel. The lamps were then lit one by one, starting at the bottom. As each new lamp was added, it and the previously lit ones blinked five times at a rate of 5 per second before remaining continuously on; each blink was accompanied by a computer beep the pitch of which increased with the height of the lit lamps in the column. This sequence of events as lit lamps

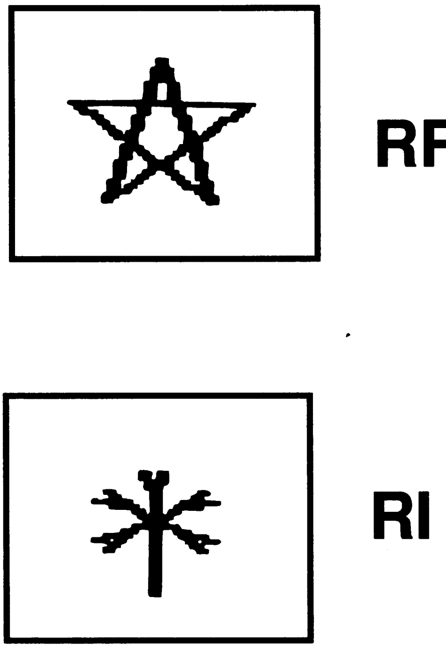

Fig. 3. Multiple-schedule stimuli as presented by the computer monitor. Two components alternated. Presses produced consequences according to a random-ratio (RR) schedule during component 1 (star, shown in top window) and according to a random-interval (RI) schedule during component 2 (tree, shown in bottom window).

were added to the column remained in effect throughout the experiment.

When all lamps of the column were lit, one of the small boxes that served as presents was inserted on the upper shelf. The lamps blinked until shortly after the present was placed and then went out. Garfield called the present to the child's attention, and then a star appeared in the upper of the two available response windows. Garfield, telling the child to watch, pressed that window and the bottom lamp turned on. Garfield then said, "Now you try." When she pressed, the second lamp turned on. Each of her next presses lit another lamp until the entire column was again lit, at which point Garfield announced the delivery of another present and withdrew. At this point, the multiple-schedule procedure was instituted.

Multiple schedule. Figure 3 shows the stimuli correlated with the two multiple-schedule components: during component 1, a star was presented on the top window (bottom window dark) and a random-ratio (RR) schedule operated; during component 2, a tree was presented on the bottom window (top window dark) and a random-interval (RI) schedule operated. Components alternated; each session began with component 1. With the change in location, whether the child was attending to the visual stimuli could be determined even when response rates in the two components were roughly equal (note, however, that following of stimulus location demonstrated control by the window that was lit but not necessarily by the stimulus that appeared in that window).

Each component lasted 60 s, excluding fixed periods during which the lamps blinked as new ones were added to the column and variable periods when presents were delivered (the latter, under experimenter control, were to allow for Garfield's entrances and exits and to insure that the child attended to the delivery of each new present). During these periods and 5-s periods between multiple-schedule components, the stimuli behind the response windows were off, presses on the response windows had no consequences, and schedules did not operate.

Multiple-schedule sessions typically lasted 4 to 6 pairs of components (10 to 20 min), though occasional sessions were shorter because of interruptions for various reasons (e.g., the child asking to leave for the bathroom, or a session extending into a time when the child had to be elsewhere); occasional sessions were extended for one or two additional pairs when a child wanted to continue (children often addressed the experimenter behind the panel, and/or Garfield even in his absence). At the end of each session, the child selected one decal for her scrapbook for each present she had earned and also chose an item from the treasure chest.

During the first session for a given child, an RR 5 schedule operated in component 1 and an RI 5-s schedule in component 2. These values were typically both increased from 5 to 8 in the second session and from 8 to 10 in the third and all subsequent sessions, except that the lower value was maintained in a component for one or more additional sessions if response rates were not well maintained in that component.

The RR schedule made each press eligible to produce a consequence with a probability equal to the reciprocal of the RR value. In the RI schedule a setup corresponded to the eligibility of the next response to produce a consequence. Once per second with a probability given by the reciprocal of the RI value in s (e.g., $p = .10$ for RI 10 s), 1 was added to available setups. If at least one setup was available, the next press on the appropriate window lit the next lamp in the column and reduced available setups by 1. Within sessions, setups accumulated at the end of one RI component were saved until the start of the next RI component. This arrangement differs from those in which RI timing stops after a single setup in two ways: latencies from scheduling to production of a consequence do not accumulate, thus reducing the difference between rates of obtained and scheduled consequences; and two or more responses in a row can produce consequences if more than one setup has accumulated. Overall, actual rates were close to the 6 lamps per 60-s component specified by the RI 10-s schedule.

The shaping of verbal behavior. The decision to shape consistent with or in opposition to the contingencies was made independently of performance, and the start of verbal shaping was based on the number of sessions for which a given child would continue to be available for the experiment rather than upon any criteria for stability of baseline performance (the final session of the experiment, with Child RT 5-02M, was conducted on the next-to-last day of school preceding the summer vacation).

At the start of verbal shaping, Garfield began to appear during an extended intercomponent interval that followed each component pair. During that time, he asked the child questions about playing the game that were designed to lead her to say that the tree worked best when pressed slowly and the star worked best when pressed fast (e.g., Garfield: "I'd like to learn how to play this game. Can you tell me how the tree works? Should I press and wait or should I press a lot without stopping." Child, after a pause: "Press and wait." Garfield, excitedly: "Oh, That sounds like a good idea. That's what I'll try when I play the game."). Thereafter, attempts were made to shape verbal elaborations that incorporated the stimuli and that included both components (e.g., Child: "When there's a tree you press and wait, and when there's a star you press a lot without stopping"). The duration of the interval varied with such factors as the progress of verbal shaping and the child's preference for interacting with Garfield or playing the game.

This procedure might be regarded as a combination of verbal prompting and/or a variety of verbal shaping in which the reinforcing consequence is provided by the listener's behavior (Greenspoon, 1955; cf. Catania et al., 1982). To the extent that Garfield's comments often included statements about properties of performance, as in the above example, the procedure might also be regarded as instructional (cf. Bentall & Lowe, 1987). It is also reasonable to assume that the situation may have included implicit demand characteristics; hand puppets as well as adults may exert such effects on the behavior of children (e.g., Moore & Frye, 1986). All of the children interacted with Garfield but knew that he was a hand puppet operated by an experimenter behind the partition (in one instance, reminiscent in its effect of the scene in which Toto pulled the curtain away from the Wizard of Oz, a child peeked around the partition and said, "Hello, Professor").

Shaping procedures varied in the consequences arranged for the child's verbal behavior. In the earliest sessions of verbal shaping, it was assumed that features of Garfield's response to the child's utterance (e.g., Garfield, enthusiastically: "Well done! That's a good guess!") would provide effective reinforcers, as in ordinary social interactions. In most later instances of verbal shaping, presents of the same sort as those provided for multiple-schedule responding were added (e.g., Garfield: "That was such a good guess that I'm going to give you an extra present!"). Unless otherwise noted, this procedure was used with all of the children for whom data are presented.

In what seemed to be the most effective procedure, though used with only one child (RT, Figure 6), a satisfactory guess had the same consequences as were scheduled for presses in the multiple schedule: turning on an additional light on the column. When this first happened, Garfield pointed this out to the child: "Look, when you said that another light came on. Why don't you try saying it again and see what happens?" Other aspects of shaping are discussed in conjunction with the presentation of data.

During verbal shaping, Garfield refrained from commenting on the relation between the child's guesses and the child's response rates. At the end of a given child's experimental participation, Garfield sometimes had an opportunity to ask about the correspondence (or lack thereof) between guesses and rates; those verbal reports, which could not be obtained systematically, were variable but usually consistent with the child's verbal behavior during sessions.

When the experimenter was satisfied that appropriate verbal behavior had been shaped, Garfield continued to appear during extended intercomponent intervals that followed each pair of components. During these conditions, Garfield asked reminder questions (e.g., "I don't remember what you told me about the star and the tree. Can you tell me again?"), and differential consequences were maintained for the child's verbal responses.

As is necessarily the case in a shaping procedure, judgments of the appropriateness of the shaped verbal behavior were made at the time consequences were arranged; taped sessions of verbal shaping were reviewed only after the experiment was concluded. It was not practical to count social and conversational reinforcers, and deliveries of presents or lit lamps varied not only with the progress of verbal shaping but also with available time, the child's rate of talking, and other uncontrollable factors. Thus, quantitative measures of the progress of shaping, as in Catania et al. (1982), were not feasible.

RESULTS

Given the exploratory nature of these procedures, details changed as a consequence of the interaction of the children and the experimenters, but variability across children makes it impractical to present the data chronologically. Figure 4 contrasts a case of successful verbal shaping (LY 5-10F) with one in which verbal shaping was unsuccessful (KE 5-11F); in both cases, however, verbal behavior was consistent with performance.

The shaping of LY's verbal behavior was initiated after eight sessions during which no systematic RR and RI rate difference had emerged. Within the first session of shaping "You press the star quickly" was established as a response to "What's the best way to make the star work?," and "You press the tree slowly" as a response to "What's the best way to make the tree work?" Corresponding rates of pressing developed within the same session; comparable verbal behavior was maintained over the next four sessions, and was accompanied by higher rates during star than during tree throughout those ses-

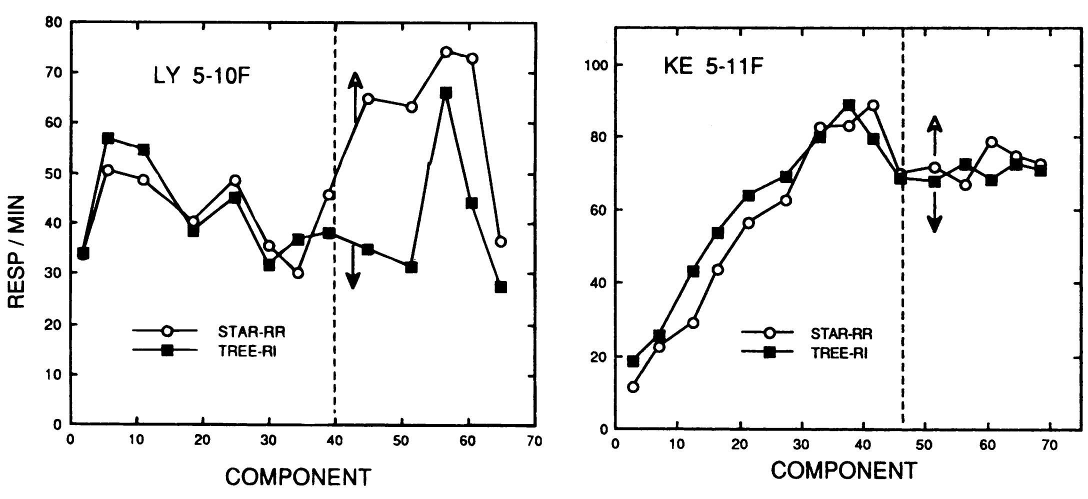

Fig. 4. Response rates during multiple-schedule components for two children. A random-ratio schedule operated during one stimulus (STAR-RR) and a random-interval schedule during the other (TREE-RI). Mean response rates over sessions are plotted against components (e.g., LY's first session included 3 presentations of each component, and data from that session are plotted at component 2). Verbal shaping began at the dashed vertical line; the direction of verbal shaping, shown by the arrows (star, fast; tree, slow), was consistent with typical RR and RI effects in contingency-shaped performances. Data from LY illustrate a maintained effect of verbal shaping on response rate, whereas those from KE illustrate performance in a case of unsuccessful verbal shaping with a highly verbal child.

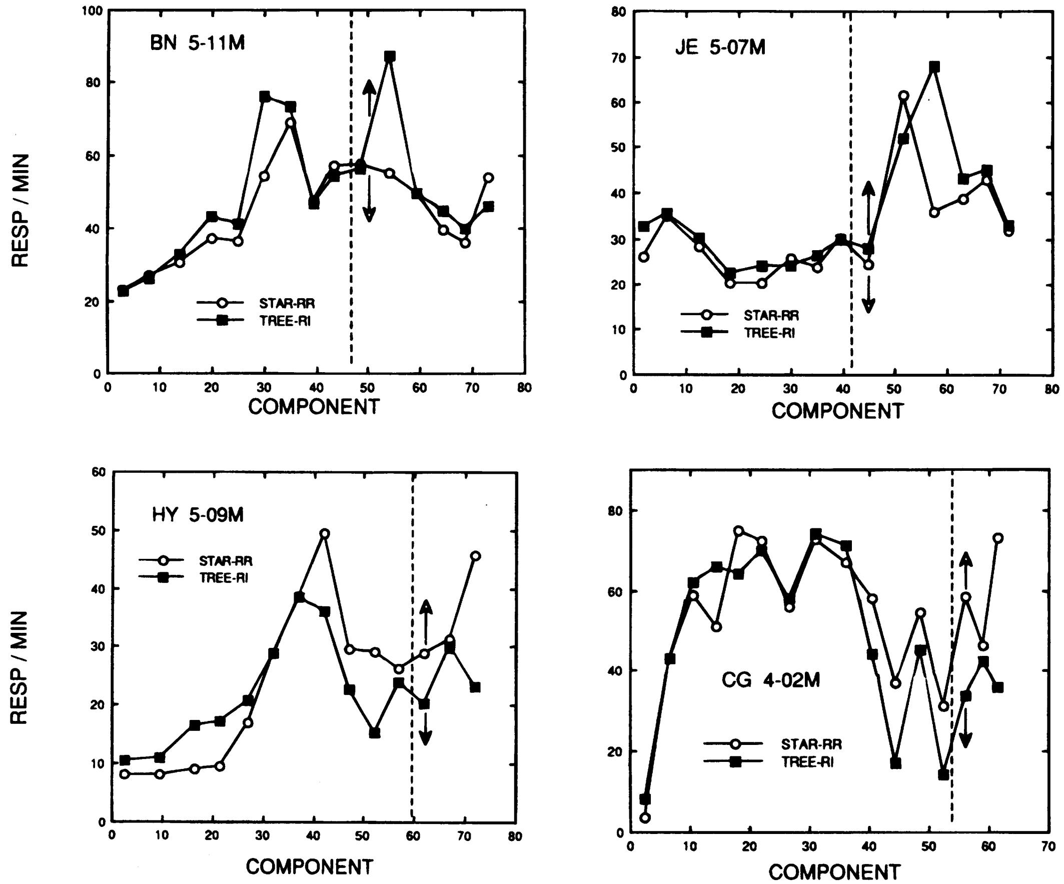

Fig. 5. Response rates during multiple-schedule components for four children, with details as in Figure 4. For both BN and JE, the direction of verbal shaping, shown by the arrows, was opposed to typical effects of RR and RI in contingency-shaped performances. For JE, slow and fast referred to speed rather than rate of hand movement; a transient effect of verbal shaping was obtained with a change of vocabulary (star, press and wait; tree, press a lot without stopping). For both HY and CG, response rates in later sessions were consistent with schedule contingencies; HY responded to yes-no questions but rarely initiated other verbal behavior, and with CG no verbal behavior was established through verbal shaping.

sions. The RR and RI rate differences in the first, second and fourth sessions of verbal shaping for LY were greater than any observed during baseline sessions across all children in the study (the largest baseline differences occurred in BN's sixth baseline session and RT's fifth; see Figures 5 and 6).

For KE, verbal shaping began after ten sessions. Her characteristic response to questions about either star or tree was "I like to press them both the same," and her response rates were consistent with that verbal behavior. It was occasionally possible to get her to say something about pressing the star fast and the tree slow, but such verbal behavior was short-lived and often followed by a correcting statement such as "I say slow but I press fast" (children often talked to Garfield during components, even though Garfield, having withdrawn behind the curtained window, was not present). Response rates increased in both components over sessions, but differential response rates were not obtained.

Figure 5 presents data from four other children. With BN (5-11M), verbal shaping was attempted in opposition to the scheduled contingencies. It began with social consequences only; these were supplemented by extra presents beginning in the fourth session of verbal shaping. Much of his verbal behavior early during verbal shaping consisted of agreement with

Garfield's statements (e.g., responding "Yes" to "Does the star work better if you press and wait?"). As shown in Figure 5, a transient rate difference occurred in the second session of verbal shaping, during which relevant verbal behavior seemed to have been established; the magnitude of this difference was larger than that in the sixth baseline session. Thereafter, however, rates during star and tree were roughly equal and verbal behavior was variable; in particular, BN's verbal responses sometimes reversed the relation between response rates and stimuli.

The data for JE (5-07M) illustrate another case in which shaping was attempted in opposition to the scheduled contingencies. The first two sessions of verbal shaping were not accompanied by corresponding changes in response rate, but topographies of pressing in the presence of star and tree were considerably different. At the beginning of the third session, Garfield asked JE to show him how to press fast or slow, and it became clear that these terms corresponded to different speeds of hand movement toward and away from the response windows, even though rates of pressing were roughly equal. For JE, as for many children at this age or younger, fast and

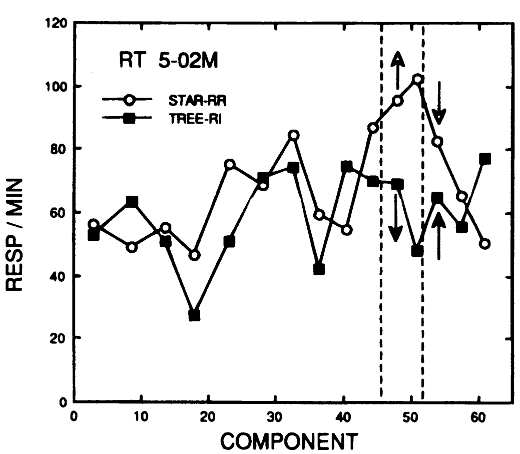

Fig. 6. Response rates during multiple-schedule components for RT, illustrating the effects of a reversal of verbal behavior. At the first dashed line, shaping established verbal behavior consistent with typical effects of RR and RI contingencies (star, press a lot without stopping; tree, press and wait). After a rate difference emerged, the direction of verbal shaping was reversed (second dashed line); as the verbal behavior changed, it was accompanied by a reversal of response rates. Details as in Figure 4.

slow applied to rate of movement through space and not to event frequencies. In the third session of verbal shaping, Garfield established "press and wait" and "press a lot without stopping" as substitutes for "fast" and "slow," and a corresponding difference in rate emerged. This difference diminished over the remaining three sessions, during which JE often failed to look at the stimuli while pressing and developed a "sing-song" patter (e.g., "with the star you press and wait, with the tree you press a lot") that was maintained during both stimuli but was unrelated to rates of pressing.

For HY (5-09M), responding was established very slowly; because of low response rates during the RR component (star), this schedule was not increased to RR 10 until session 5 (component 25). Verbal shaping, consistent with contingencies, was attempted beginning with session 12, but virtually all of HY's verbal behavior consisted of yes or no responses to Garfield's questions; questions for which yes or no responses were inappropriate were typically unanswered. Nevertheless, a rate difference emerged, but it had been evident prior to verbal shaping and might best be regarded as behavior under the differential control of the RR and RI contingencies.

The only other case in which such behavior was observed was with the youngest child studied, CG (4-02M). For this child, higher rates on the RR than on the RI schedule emerged by session 10, and over the remaining seven sessions rates maintained by the RR schedule (star) were roughly 50% higher than those maintained by the RI schedule (tree): 51 and 33 responses per min, respectively. Rates were variable, however, and included substantial rates of dark-window and intercomponent pressing. Attempts at verbal shaping were aimed not only at statements about differential responding in the presence of each stimulus, but also at statements about looking at the stimuli while pressing. This shaping too was unsuccessful, however. The differential RR and RI rates are therefore presumably instances of contingency-shaped responding.

Figure 6 shows data obtained when the lighting of column lamps was substituted for social consequences and extra presents in shaping the verbal behavior of RT (5-02M). In this instance, the shaping was sufficiently effective that it was possible to arrange a reversal. First, verbal behavior that was consistent with contingencies was shaped. This shaping was accompanied by a corresponding separation of response rates; the RR and RI rate difference in the second session of shaping (more than 50 responses/min) was the largest obtained for any child in any session throughout the study. A reversal of the shaping, so that the verbal behavior was opposed to the differential effects of RR and RI contingencies, began two sessions later. The reversal of the verbal behavior was accompanied by a gradual reversal of response rates.

Data have been presented for 7 of the 14 participants in the experiment. The remaining seven ranged in age from 4-04 to 5-11. For various reasons (see Method), sessions were discontinued prior to verbal shaping for five of those. No systematic differences in RR and RI response rates emerged in any of those cases, and their data are not relevant to conclusions about the relation between nonverbal behavior and shaped verbal behavior (in a comparable situation with nonhuman subjects, such instances would probably not even enter into a data presentation; for example, the report of a study of schedule effects on the key-pecking of pigeons would not ordinarily mention a pigeon who was excluded from the experiment because of a problem in the shaping of its key pecks).

Of the remaining two, in the case of ZA (5-11F), Garfield switched to direct instructions after two or three sessions of unsuccessful verbal shaping (e.g., Garfield: "Try pressing the star a lot without stopping"). This intervention produced differential response rates but confounded the effects of the direct instructions with those of verbal shaping (for studies of the effects of instructions on schedule performances, see Baron & Galizio, 1983; Hayes, Brownstein, Haas, & Greenway, 1986; LeFrancois, Chase, & Joyce, 1988). Finally, in the case of NA (5-08F), verbal shaping was discontinued when it became clear that the data would be uninterpretable because of substantial variability in response rates. The variability came about because NA frequently paused for long periods of time to count and recount lights and presents during multiple-schedule components.

In summary, verbal shaping correlated with corresponding changes in nonverbal responding was demonstrated in at least three cases: LY, JE (transiently with respect to response rate, but also with a change in topography that followed a change in verbal behavior) and RT (including a reversal). Although verbal shaping was unsuccessful with KE, her verbal behavior was consistent with her performance, and the ambiguous verbal shaping for BN was accompanied by a transient rate difference. In the remaining two cases, HY and CG, verbal shaping was unsuccessful and performance was characteristic of contingency-shaped rather than rule-governed behavior. Furthermore, some of the RR and RI rate differences that followed verbal shaping were larger than those obtained in any baseline sessions, and there were no instances of rate differences that were opposed to rather than consistent with verbal behavior.

DISCUSSION

The present experiments should be taken mainly as demonstrations. They show that some varieties of verbal behavior can be shaped with 4-yr-old to 6-yr-old children, and that such verbal behavior is sometimes correlated with changes in corresponding nonverbal behavior. The verbal behavior was produced by shaping before the corresponding nonverbal behavior emerged, thereby establishing that the direction of control was from verbal behavior to nonverbal. Furthermore, verbal behavior was sometimes accompanied by differential response rates that were opposed, even if only transiently, to the effects of RR and RI contingencies. In such cases, it is appropriate to refer to the nonverbal behavior as rule-governed. The results were variable, but that variability is what should be expected if the ages at which adult correlations between verbal and nonverbal behavior begin to develop are within the range of ages included in this study.

It is tempting to conclude from these findings that it is more difficult to shape verbal behavior in opposition to RR and RI contingencies than consistent with them, or that the effectiveness of verbal shaping varies depending on whether social or concrete consequences were used, or that different outcomes consistently depend on age, gender, or other individual differences. It would be inappropriate to try to summarize these results in such terms, however, because the verbal shaping procedure and, perhaps more important, the experimenter's skill in verbal shaping, evolved over the group of children with whom it was used and were perhaps as important as other sources of variability in these procedures. The evolving procedures are relevant to the art of verbal shaping, but there is no a priori reason to assume that the observed correlations between verbal and nonverbal behavior should be evaluated differently depending on the efficiency with which shaping established the verbal behavior.

One assumption implicit in the demonstrations is that sensitivity to the RR and RI contingencies would have occurred with nonhuman subjects. But cross-species comparisons involve problems of equating the potency of reinforcers, the effectiveness of stimuli, the integrity of response classes, and so on. A comparison across children is more appropriate than comparisons across species, and it is therefore worth noting that the demonstrations include both cases that seem to qualify as examples of contingency-shaped behavior and those that seem to qualify as examples of rule-governed behavior.

Insensitivity to the RR and RI contingencies might also be attributed to the limited potency as reinforcers of the consequences arranged for the nonverbal behavior. As with comparisons across species, problems are raised by comparisons across procedures, ages, and so on. Yet the consequences that maintained pressing in these procedures were the same as those used in the successful shaping of verbal behavior, and to that extent were functional and not merely nominal reinforcers. This is consistent with the rule of thumb that verbal behavior is typically contingency-shaped in adult human behavior even though much nonverbal behavior is rule-governed (perhaps because human verbal communities have not established extensive vocabularies concerned with the determinants of verbal behavior; cf. Catania, Shimoff, & Matthews, 1989; Skinner, 1957).

In the vocabulary of verbal behavior (Skinner, 1957), the verbal behavior that was shaped in these procedures might be characterized as intraverbal (though it may also have included substantial autoclitic components). To the extent that a word such as "tree" occasions "press and wait," the latter utterance might occur once "tree" is emitted as a tact during the relevant multiple-schedule component. But "tree" as part of an intraverbal sequence and "tree" as a tact are members of different operant classes, and the ways in which different verbal classes with similar topographies can come to share their functions are just beginning to be elaborated (cf. Stafford, Sundberg, & Braam, 1988; Watkins, Pack-Teixteira, & Howard, 1989).

Even if this aspect of the performance is resolved, it remains to demonstrate how the utterance "press and wait" might then occasion the corresponding nonverbal behavior. In other words, there is still much to learn about the contingencies that bring about correspondences between saying and doing (Risley & Hart, 1968). The contingencies that may shape such correspondences are necessarily more complex than those that operate separately on the saying and on the doing (cf. Baer, Detrich, & Weninger, 1988; Matthews, Shimoff, & Catania, 1987). Furthermore, relations between verbal and nonverbal behavior involve both directions of control: from verbal to nonverbal, as in some of the present cases, and vice versa, as when one accurately describes one's own behavior.

Say-do correspondences share this symmetry with equivalence classes (Sidman, Wynne, Maguire, & Barnes, 1989), and it may be appropriate to speculate that these two types of classes are functionally as well as formally related.

In any case, the present demonstrations set the stage for more precise characterizations of the verbal behavior of children and the sharper definition of verbal shaping and other experimental details. With the standardization of such procedures, the monitoring of nonverbal performances such as those in the present multiple schedules might provide a tool for analyzing how the functional properties of verbal behavior and its correlations with nonverbal behavior develop.

The demonstration of contingency-shaped or rule-governed multiple RR RI performances by children of different ages, with or without verbal shaping, may have applied relevance. For example, consider how obtaining one rather than the other performance from a nonverbal institutionalized child might influence the prognosis for establishing verbal behavior through a language program for that child. The distinction between rule-governed versus contingency-shaped may also be useful in diagnosis and perhaps even in treatment, to the extent that performance differences turn out to be correlated with behavioral deficits (e.g., aphasia) or other diagnostic categories (e.g., autism).

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